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(54) **WIPER SUPPORT DEVICE FOR A PHASE SHIFTER COMPRISING A WIPER SUPPORT RESILIENTLY COMPRESSED BETWEEN A SUBSTRATE AND A COVER**

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H01Q 3/32 (2006.01)

(52) **U.S. Cl.**
CPC ***H01P 1/184*** (2013.01); *H01Q 3/32* (2013.01)

(58) **Field of Classification Search**
CPC H01P 1/184; H01P 1/18
USPC 333/161, 156
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,344,827	B2 *	1/2013	Kim et al.	H01P 1/184 333/156
2006/0077098	A1 *	4/2006	Zimmerman	H01Q 3/32 342/372
2011/0063049	A1 *	3/2011	Bradley et al.	H01P 1/184 333/161
2011/0140805	A1 *	6/2011	Liu et al.	H01P 1/184 333/161
2016/0301121	A1 *	10/2016	Dandlberger et al.	H01P 1/064

* cited by examiner

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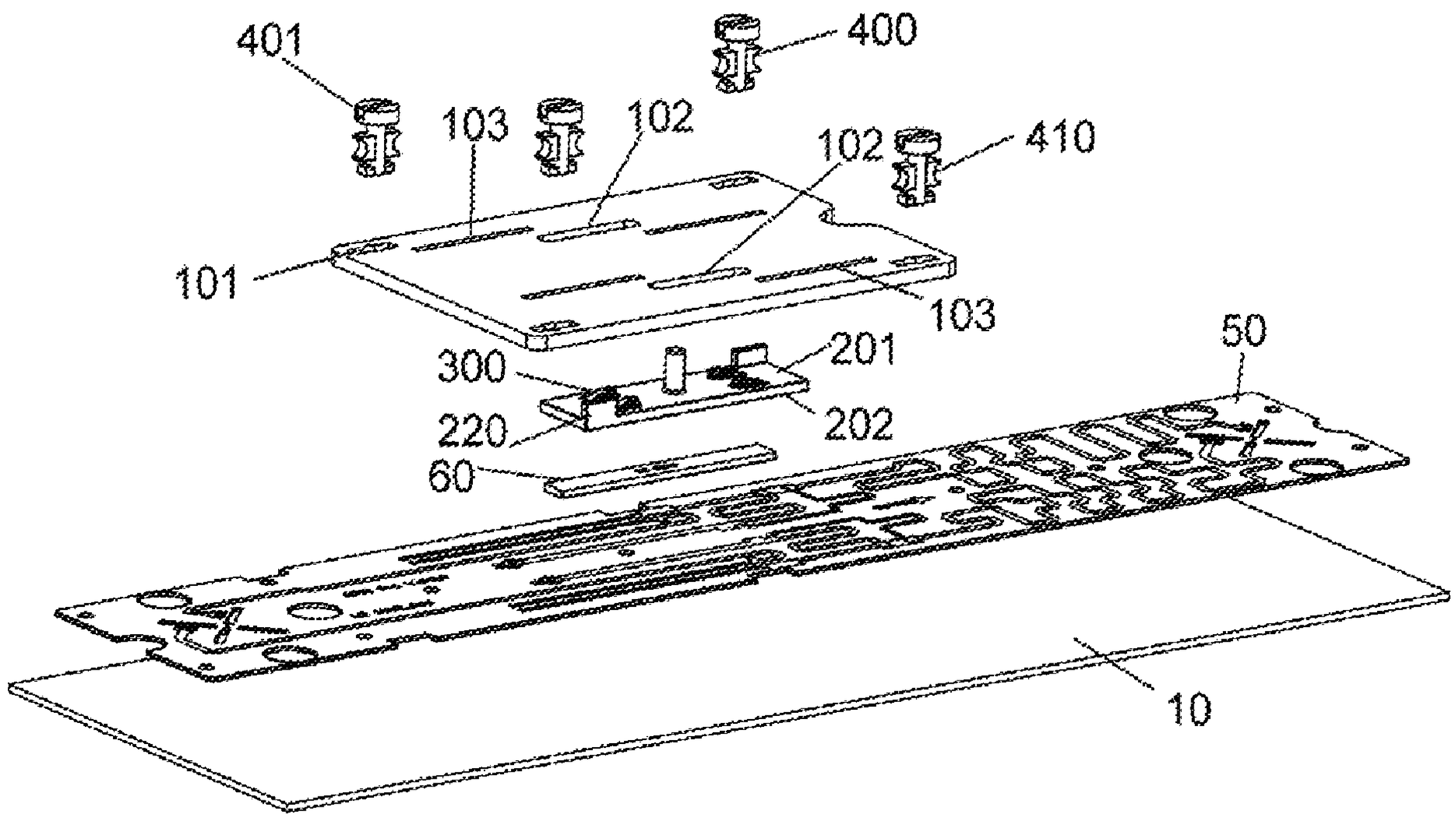
(57) **ABSTRACT**

There is provided a wiper support device for a phase shifter including a substrate. The wiper support device may comprise a cover, which is provided opposite to the substrate. The wiper support device may further comprise a wiper support, which is located between the cover and the substrate. The wiper support has a first surface facing the cover and a second surface facing the substrate. The second surface may be fixed with a wiper. The wiper support device may further comprise a resilient element, which extends from the first surface of the wiper support toward the cover and abuts against the cover. The wiper support device may further comprise a fastening mechanism, which connects the cover to the substrate. The resilient element may be compressed between the cover and the wiper support.

20 Claims, 6 Drawing Sheets



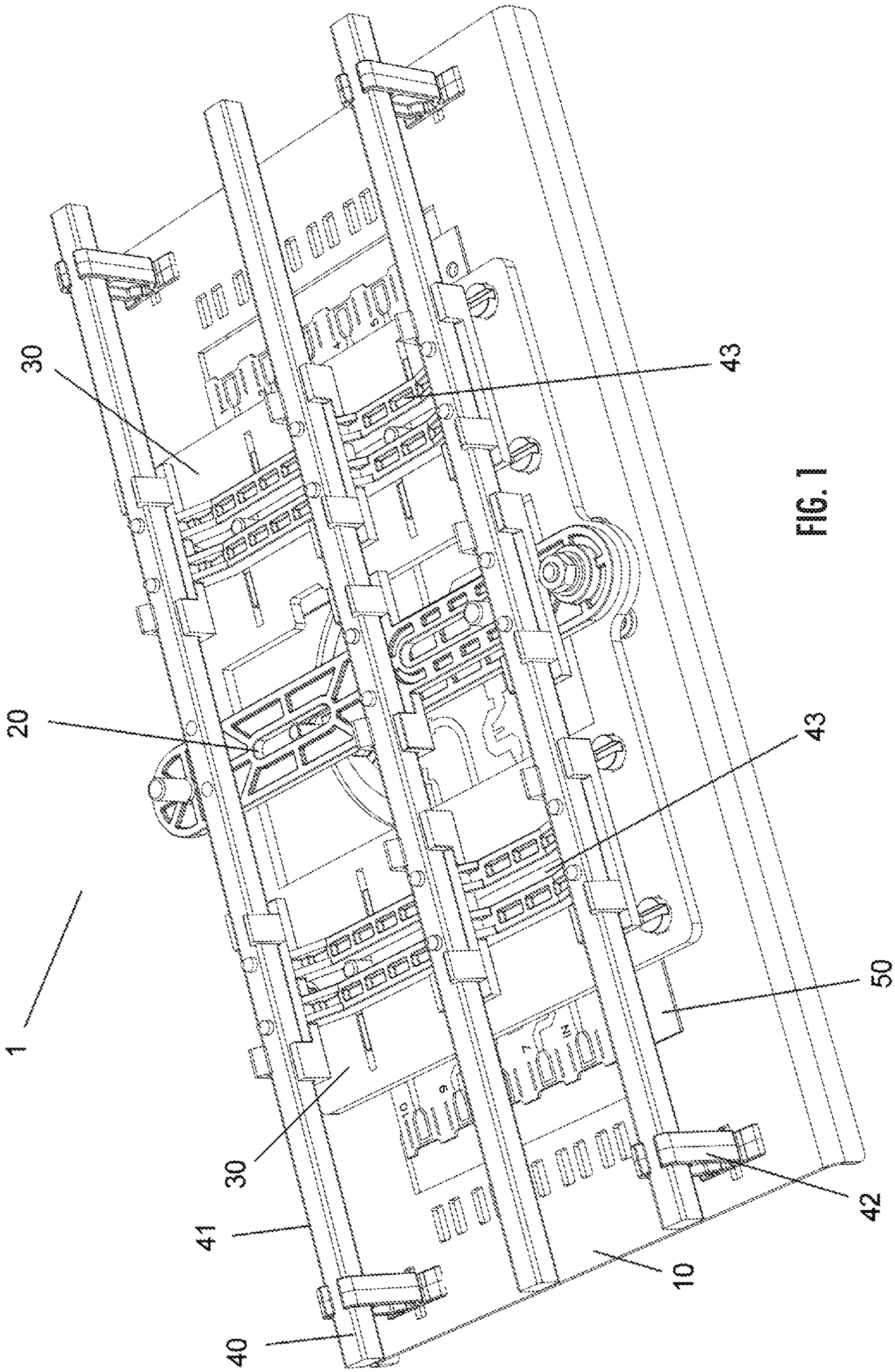


FIG. 1

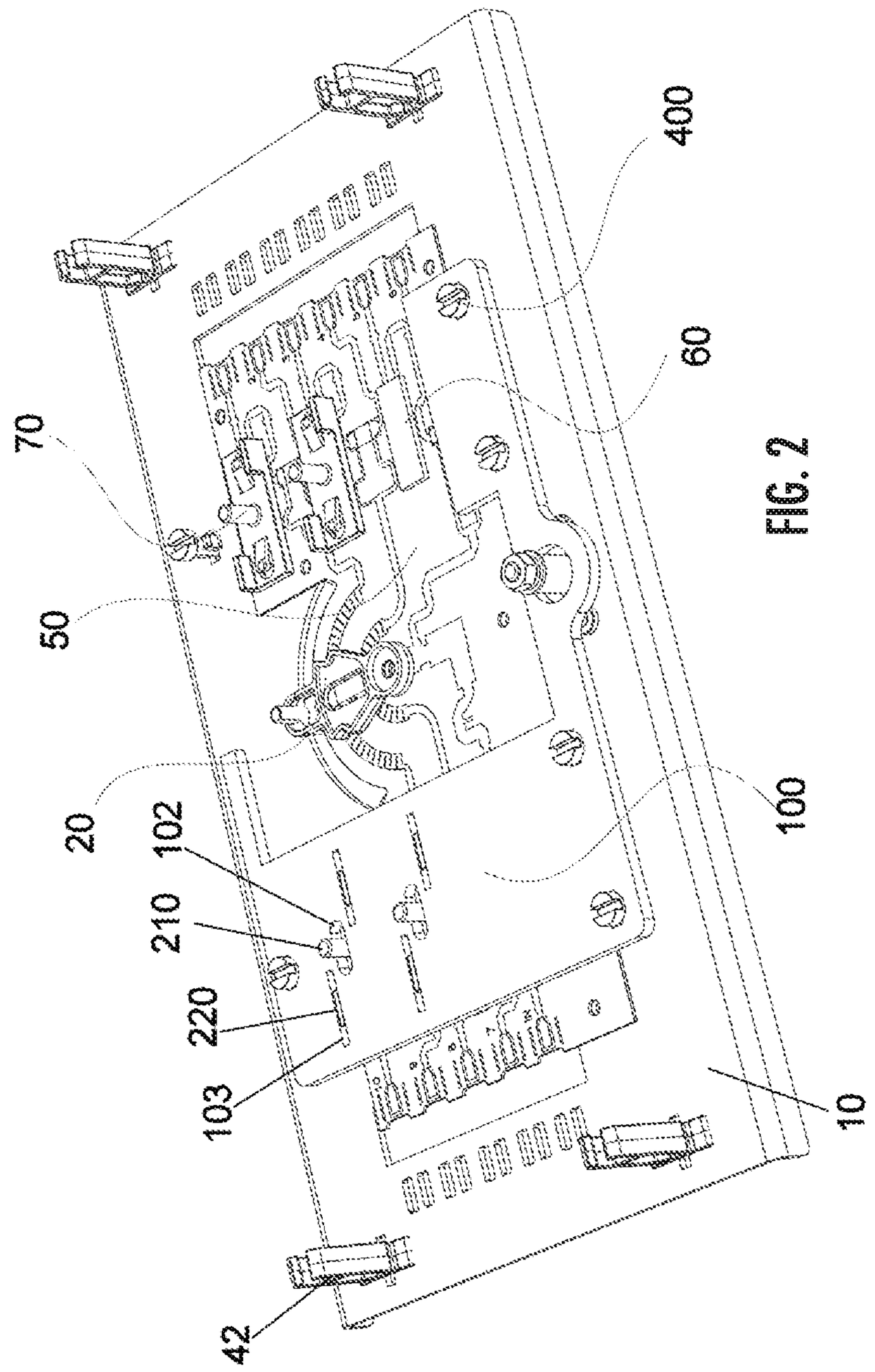


FIG. 2

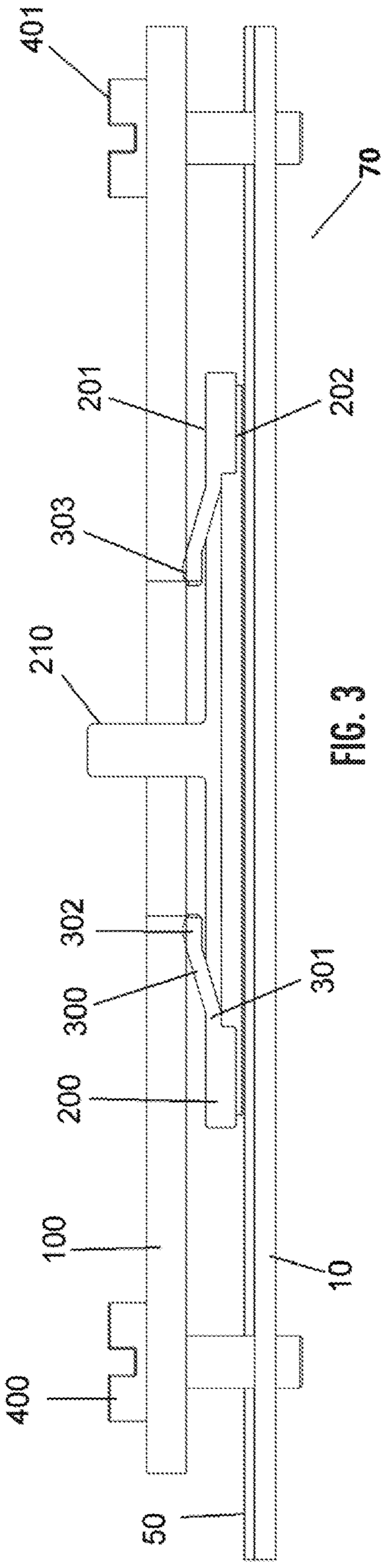


FIG. 3

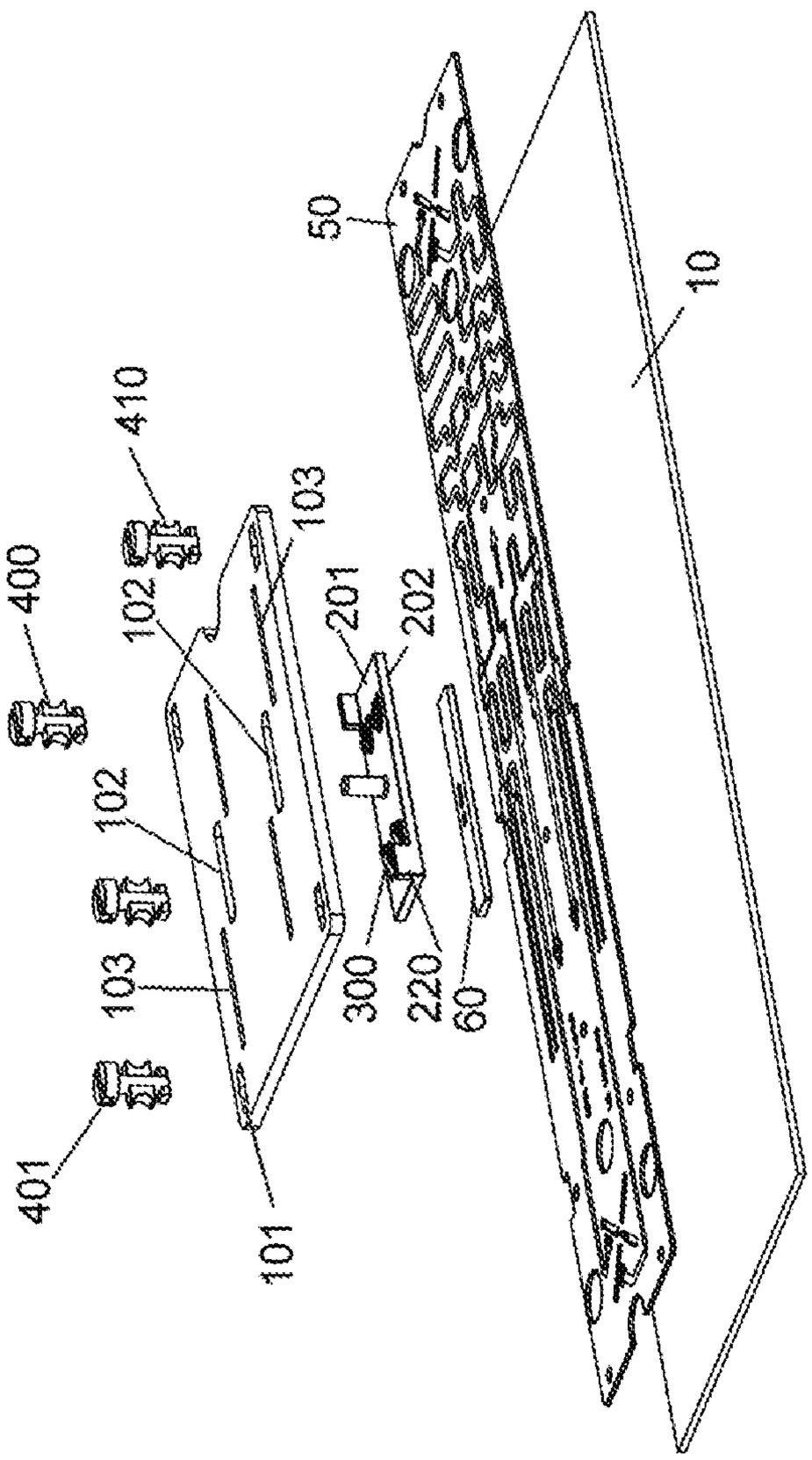


FIG. 4

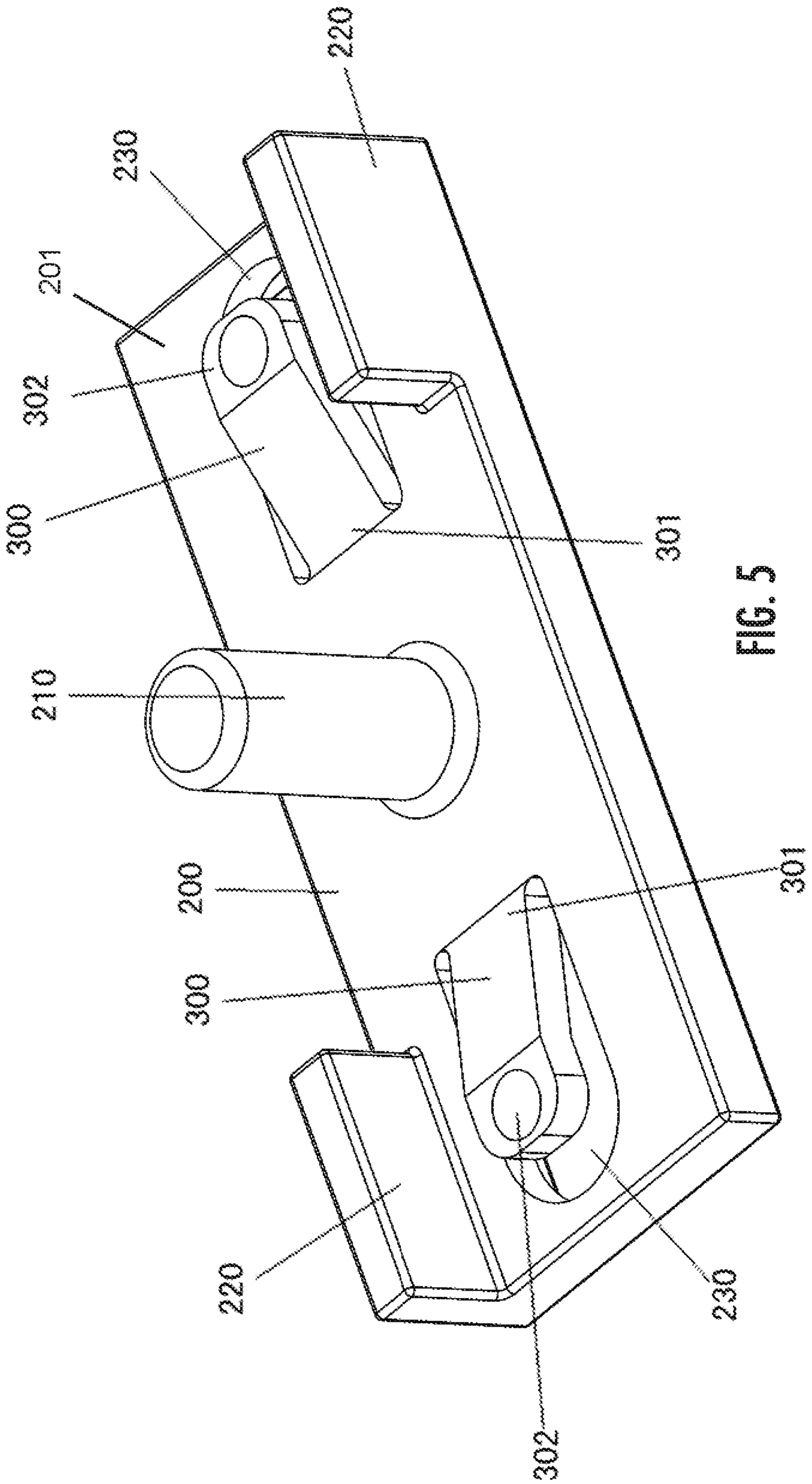


FIG. 5

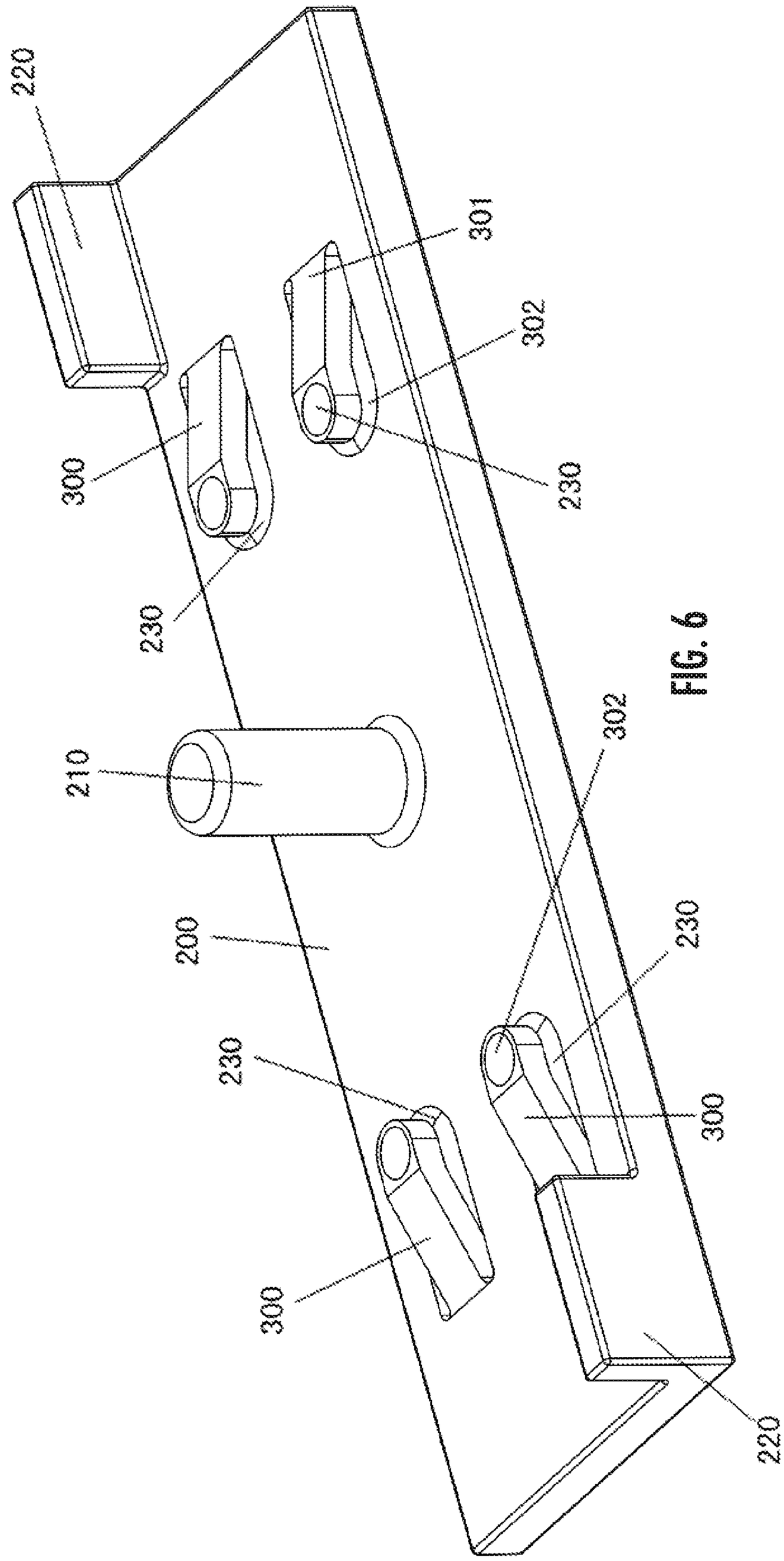


FIG. 6

WIPER SUPPORT DEVICE FOR A PHASE SHIFTER COMPRISING A WIPER SUPPORT RESILIENTLY COMPRESSED BETWEEN A SUBSTRATE AND A COVER

RELATED APPLICATION

The present application claims priority from and the benefit of Chinese Patent Application No. 20180081467.1, filed Jan. 29, 2018, the disclosure of which is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

The present disclosure generally relates to a phase shifter. More specifically, the present disclosure relates to a wiper support device for a phase shifter.

BACKGROUND OF THE INVENTION

A phase shifter is a device capable of adjusting a phase of a wave. There are wide applications in such fields as radar, missile attitude control, communication, instrument and even music. The phase shifter, which organically combines transformer phase shift technology and the digital measurement technology, presents a high-precision phase shift adjustment, an accurate and visual reading, an adjustable output voltage and current, a favorable output waveform, a reliable operation and a convenient operation, so that the phase shifter can satisfy testing and checking of such instruments as single-phase and three-phase AC power and phase with a high precision, and can also be used in a test device of a meter.

In general, the phase shifter includes a wiper that presses against a PCB (printed circuit board) and is movable relative to the PCB to change a phase. It is known that, in an existing phase shifter, one end of the wiper is fixed relative to the PCB to serve as a center of rotation and the other end is rotatable about the center of rotation, thereby enabling the wiper to rotate with respect to the PCB.

The cost of the PCB is proportional to the area of the PCB; that is, the greater the area of PCB is, the higher the cost will normally be. Thus, a smaller phase shifter presents a cost advantage over a larger phase shifter. However, for a phase shifter, the use of the above-described rotary operation principle normally results in a larger size of the phase shifter, thus causing an increase in the cost.

SUMMARY OF THE INVENTION

One object of the present disclosure is to provide a wiper support device capable of overcoming at least one drawback in the prior art.

Another object of the present disclosure is to provide a phase shifter comprising the above-described wiper support device.

According to an aspect of the present disclosure, there is provided a wiper support device for a phase shifter including a substrate. The wiper support device may comprise a cover, which is provided opposite to the substrate. The wiper support device may further comprise a wiper support, which is located between the cover and the substrate. The wiper support has a first surface facing the cover and a second surface facing the substrate. The second surface may be affixed with a wiper. The wiper support device may further comprise a resilient element, which extends from the first surface of the wiper support toward the cover and abuts against the cover. The wiper support device may further comprise a fastening mechanism, which connects the cover to the substrate. The resilient element may be compressed between the cover and the wiper support.

In one embodiment of the wiper support device, the resilient element may extend obliquely towards the cover with respect to the first surface of the wiper support and is movable relative to the cover on a surface of the cover.

In one embodiment of the wiper support device, the resilient element may be a resilient finger extending from the first surface of the wiper support toward the cover, one end of which resilient finger is fixed to the first surface of the wiper support, and the other end of which resilient finger is a free end abutting against the cover and movable on a surface of the cover relative to the cover.

In one embodiment of the wiper support device, the wiper support may be provided with a cutout, within which the resilient element is located when viewed along a direction perpendicular to the first surface such that the resilient element, when compressed, is deformable towards the cutout so as to enter into the cutout. The advantage of such configuration lies in that the space required for the deformation of the resilient element can be saved, so that the wiper support device is more compact.

In one embodiment of the wiper support device, the free end may have a flat contact surface which is remained in contact with the surface of the cover facing the wiper support, so as to form a face contact between the resilient element and the cover.

In one embodiment of the wiper support device, the free end may have a projection which remains in contact with the surface of the cover facing the wiper support, so as to form a point contact between the resilient element and the cover.

In one embodiment of the wiper support device, the wiper support may be provided with a guide pin, and the cover may be provided with a guide slot, the guide pin passing through the guide slot and being movable within the guide slot.

In one embodiment of the wiper support device, the end of the guide slot may serve as a stop to limit a movement of the guide pin.

In one embodiment of the wiper support device, the guide pin may be centrally disposed on the wiper support.

In one embodiment of the wiper support device, the cover may be connected to the substrate via the fastening mechanism such that a distance between the cover and the substrate is associated with a degree at which the resilient element is compressed.

In one embodiment of the wiper support device, the fastening mechanism may comprise an adjusting means, which is configured to adjust a distance between the cover and the substrate.

In one embodiment of the wiper support device, a PCB may be fixed on the substrate, and the wiper may abut against the PCB, wherein the wiper is completely covered by the second surface of the wiper support. In the case that the second surface of the wiper support completely covers the wiper, the pressing force on the wiper support produced due to the compression of the resilient element can be uniformly applied to the entire wiper so that the pressure between the wiper and the PCB is uniform.

In one embodiment of the wiper support device, the cover, the wiper support and the substrate may be arranged parallel to each other and remain arranged in parallel during operation of the phase shifter. In this case, the distance between the cover and the substrate always maintains uniform so that the pressure between the wiper and the PCB is uniform.

In one embodiment of the wiper support device, the wiper support device may comprise a plurality of resilient elements, which are arranged in a regular manner on the wiper support. Such resilient elements may have the same configuration, and/or may be arranged symmetrically around a center of the guide pin. In this case, it can help to maintain a uniform pressure between the wiper and the PCB.

In one embodiment of the wiper support device, the wiper support may be provided with a positioning member, and the cover may be provided with a positioning slot. When the wiper support device is assembled, the positioning member may extend into the positioning slot.

According to another aspect of the present disclosure, there is provided a phase shifter, which comprises a driving mechanism and the wiper support device as described above, wherein the driving mechanism may be configured to drive the wiper support.

In one embodiment of the phase shifter, the driving mechanism may include a pull rod and a pull rod connector fixedly connected to the pull rod, the pull rod connector being configured to drive the wiper support.

In an embodiment of the phase shifter, the driving mechanism may include a pull rod and a pull rod support, in which the pull rod support is fixed on the substrate, and the pull rod is slidably coupled to the pull rod support.

In one embodiment of the phase shifter, the phase shifter may be provided with a plurality of wiper support devices that share a cover.

According to the wiper support device of the present disclosure as well as the phase shifter comprising the wiper support device, the size of the phase shifter may be greatly reduced by using such a configuration that the wiper slides on the PCB, so as to lower cost.

BRIEF DESCRIPTION OF THE DRAWINGS

After reading the embodiments below in combination with the accompany drawings, a plurality of aspects of the present disclosure will be better understood. In the accompany drawings:

FIG. **1** is a perspective view of the phase shifter according to the present disclosure;

FIG. **2** is a partial perspective view of the phase shifter according to the present disclosure;

FIG. **3** is a cross-sectional view of the wiper support device according to the present disclosure;

FIG. **4** is an exploded perspective view of the wiper support device according to the present disclosure;

FIG. **5** is a perspective view of one embodiment of a wiper support of the wiper support device according to the present disclosure; and

FIG. **6** is a perspective view of another embodiment of a wiper support of the wiper support device according to the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

The present disclosure will be described as follows with reference to the accompanying drawings, in which certain embodiments of the present disclosure are shown. However, it is to be understood that the present disclosure may be embodied in many different forms and should not be construed as limited to the embodiments that are pictured and described herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. It will also be appreciated that the embodiments disclosed herein can be combined in any way to provide many additional embodiments.

Like numbers refer to like elements throughout. In the figures, the thickness of certain lines, layers, components, elements or features may be exaggerated for clarity.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the specification and relevant art and should not be interpreted in an idealized or overly formal sense unless expressly so defined herein. Well-known functions or constructions may not be described in detail for brevity and/or clarity.

As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. As used herein, phrases such as "between X and Y" and "between about X and Y" should be interpreted to include X and Y. As used herein, phrases such as "between about X and Y" mean "between about X and about Y" As used herein, phrases such as "from about X to Y" mean "from about X to about Y."

It will be understood that when an element is referred to as being "on", "attached" to, "connected" to, "coupled" with, "contacting", etc., another element, it can be directly on, attached to, connected to, coupled with or contacting the other element or intervening elements may also be present. In contrast, when an element is referred to as being, for example, "directly on", "directly attached" to, "directly connected" to, "directly coupled" with or "directly contacting" another element, there are no intervening elements present. It will also be appreciated by those of skill in the art that references to a structure or feature that is disposed "adjacent" another feature may have portions that overlap or underlie the adjacent feature.

Spatially relative terms, such as "under", "below", "lower", "over", "upper", "lateral", "left", "right" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is inverted, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the descriptors of relative spatial relationships used herein interpreted accordingly.

Referring now to the drawings, FIG. **1** shows one example of the phase shifter **1**. As shown in the drawings, the phase shifter **1** comprises a substrate **10**, a primary phase shifter **20**, a secondary phase shifter **30**, and a driving mechanism

40. In the following description, a direction along a width of the phase shifter is referred to as a transverse direction, a direction along a length of the phase shifter is referred to as a longitudinal direction, and a direction along a height of the phase shifter is referred to as a vertical direction.

The substrate **10** is a substantially plate-shaped member, and the PCB **50** is fixed on the substrate **10**. The primary phase shifter **20** and the secondary phase shifter **30** are arranged above the PCB **50**. The primary phase shifter **20** and the secondary phase shifter **30** may be arranged in a conventional manner. For example, as shown in FIG. **1**, the primary phase shifter **20** and the secondary phase shifter **30** are arranged side by side.

The primary phase shifter **20** and the secondary phase shifter **30** each include a wiper **60** (see FIG. **2**), which is configured to abut the PCB **50**, and is movable with respect to the PCB **50** to thereby effect a phase change.

The driving mechanism **40** is operatively coupled with the primary phase shifter **20** and the secondary phase shifter **30**, so as to drive operation of the primary phase shifter **20** and the secondary phase shifter **30**. The primary phase shifter **20** and the secondary phase shifter **30** each have a wiper support device on which the wipers **60** are respectively supported. The driving mechanism **40** drives the wiper support device, thus driving movement of the wiper **60** relative to the PCB **50**.

In an embodiment, the driving mechanism **40** includes a pull rod **41** and a pull rod support **42**, in which the pull rod support **42** is fixed on the substrate **10**, and the pull rod **41** is slidably coupled to the pull rod support **42**. As shown in FIGS. **1** and **2**, the pull rod **41** is arranged along a longitudinal direction and movable along the longitudinal direction.

The driving mechanism **40** further includes a pull rod connector **43** fixedly connected to the pull rod **41**. As shown in FIG. **1**, the pull rod connector **43** is substantially transverse to the pull rod **41**, and the movement of the pull rod **41** causes movement of the pull rod connector **43**. The pull rod connector **43** is operatively coupled with the primary phase shifter **20** and the secondary phase shifter **30**, and more specifically, operatively coupled with the wiper support device. Accordingly, the movement of the driving mechanism **40** causes movement of the wiper support device, which in turn causes movement of the wiper **60** relative to the PCB **50**.

The primary phase shifter **20** and the secondary phase shifter **30** may use the same or different configurations. In the illustrated embodiments, the primary phase shifter **20** and the secondary phase shifter **30** use different structures. However, this is not restrictive, but merely exemplary. As shown in FIGS. **1** and **2**, the secondary phase shifter **30** (FIG. **1**) uses a sliding configuration which comprises the wiper support device **70** (FIG. **2**) according to the present disclosure. The wiper support device **70** (FIG. **2**) which supports the wiper **60** (FIG. **2**), is operatively coupled with the driving mechanism **40** (FIG. **1**) to cause the wiper **60** (FIG. **2**) to slide relative to the PCB **50** (FIG. **2**). The wiper support device **70** (FIG. **2**) according to the present disclosure will be described in detail below.

Referring now to FIGS. **3** and **4**, FIG. **3** shows one example of the wiper support device **70** (FIG. **2**). As shown in the drawings, the wiper support device **70** serves to support the wiper **60** in the phase shifter such that the wiper **60** is slidable with respect to the PCB, thereby changing a phase. The wiper support device **70** includes a cover **100** (FIG. **3**), a wiper support **200** (FIG. **3**), a resilient element **300**, and a fastening mechanism **400**.

As shown in FIG. **3**, the cover **100** is a substantially plate-shaped member and disposed opposite to the substrate **10**. The cover **100** is connected to the substrate **10** through the fastening mechanism **400** such that the cover **100** is positioned parallel to the substrate **10** but spaced apart from each other, thereby forming certain distance between the cover **100** and the substrate **10**.

In one embodiment, the fastening mechanism **400** may include a fastener **401**. As shown in FIG. **4**, the fastening mechanism **400** includes four fasteners **401**, which are respectively located at four corners of the cover **100**. At the four corners of the cover **100**, there are provided through holes **101** for the fasteners **401**, through which the fasteners **401** pass correspondingly.

At corresponding positions on the substrate **10**, there are also provided with perforations, through which the fasteners **401** pass correspondingly. In this way, the fastener **401** passes through the through hole **101** of the cover **100** and the perforation of the substrate **10** so as to connect the cover **100** to the substrate **10**.

The wiper support **200** is located between the cover **100** and the substrate **10**, as shown in FIG. **3**. In one embodiment, the wiper support **200** is also a generally plate-shaped member having a first surface **201** facing the cover **100** and a second surface **202** facing the substrate **10**. The wiper **60** is fixed to the second surface **202** of the wiper support **200**. A person skilled in the art should understand that, the wiper **60** may be fixed to the second surface **202** by any suitable means, for example, the wiper **60** may be directly adhered to the second surface **202**.

As described above, the driving mechanism **40** is operatively coupled with the wiper support device **70**. Accordingly, the movement of the driving mechanism **40** causes movement of the wiper support device **70**, which in turn causes movement of the wiper **60** relative to the PCB **50**.

To this end, a coupling mechanism is provided on the wiper support device **70**. Specifically, according to one embodiment, the coupling mechanism is in the form of a guide pin **210** (FIGS. **3**, **5** and **6**). As shown in FIGS. **3-6**, the guide pin **210** is substantially centrally disposed on the wiper support **200**. In one embodiment, the guide pin **210** is fixed to the wiper support **200**. In another embodiment, the guide pin **210** is integrally formed with the wiper support **200**.

As shown in FIGS. **5** and **6**, the guide pin **210** which is disposed on the first surface **201** of the wiper support **200**, extends from the first surface **201** toward the cover **100** (FIG. **3**). The cover **100** (FIG. **3**) is provided with a guide slot **102** (FIG. **4**), through which the guide pin **210** passes such as to protrude from the guide slot **102** (FIG. **4**). The guide slot **102** (FIG. **4**) may use various types of shapes and sizes. The guide slot **102** (FIG. **4**), which extends along a longitudinal direction, is shaped and sized to match a movement range of the guide pin **210**, so that the guide pin **210** is movable within the guide slot **102** (FIG. **4**). In addition, the guide slot **102** (FIG. **4**) may be configured to define a movement range of the guide pin **210**. For example, both ends of the guide slot **102** (FIG. **4**) may serve as a stop to limit further movement of the guide pin **210**.

The portion of the guide pin **210** protruding from the guide slot **102** is operatively coupled with the driving mechanism **40**, and specifically, operatively coupled with the pull rod connector **43**. As a result, the pull rod **41** of the driving mechanism **40** moves along a longitudinal direction, causing the pull rod connector **43** to move along a longitudinal direction and driving the guide pin **210** to move along a longitudinal direction within the guiding slot **102**, so as to

allow that the wiper support **200** moves along a longitudinal direction, and in turn to allow that the wiper **60** fixed on the second surface **202** of the wiper support **200** in the case of abutting against the PCB **50** moves relative to the PCB **50** along a longitudinal direction.

The resilient element **300** which is located between the cover **100** and the wiper support **200**, extends from the first surface **201** of the wiper support **200** toward the cover **100** and eventually abuts the cover **100**.

As shown in FIG. **3**, the resilient element **300** extends obliquely toward the cover **100** relative to the first surface **201** of the wiper support **200**. The distal end of the resilient element **300** abuts the cover **100**, and is movable on a surface of the cover **100** facing the wiper support **200**.

In one embodiment, the resilient element **300** may be in the form of, for example, a resilient finger, extending from the first surface **201** of the wiper support **200** toward the cover **100**. One end of the resilient finger is a fixed end **301**, which is fixed to the first surface **201** of the wiper support **200**, or which is formed integrally with the wiper support **200**. The other end of the resilient finger is a free end **302**, which abuts the cover **100** and is movable with respect to the cover **100** on a surface of the cover **100** facing the wiper support **200**.

FIG. **5** shows one embodiment of the wiper support **200** and the resilient element **300**, and FIG. **6** shows another embodiment of the wiper support **200** and the resilient element **300**. In the embodiments shown in FIGS. **5** and **6**, the fixed end **301** of the resilient member **300** is formed integrally with the wiper support **200**. The wiper support **200** is formed with a cutout **230**, at one end of which the fixed end **301** of the resilient element **300** is located. Viewed along a direction perpendicular to the first surface **201**, the resilient element **300** is located within the cutout **230**, so that the resilient element **300** when compressed may be deformed towards the cutout **230** so as to enter the cutout **230**. The advantage presented by such configuration lies in that it is possible to further save a space required for accommodating the resilient element **300** to perform resilient deformation, such that the structure of the wiper support device **70** is more compact.

In addition, FIGS. **5** and **6** respectively show different extension manners of the resilient element **300**. In FIG. **5**, the resilient element **300** extends from the first surface **201** of the wiper support **200** toward the cover **100** and away from the guide pin **210**, whereas in FIG. **6**, the resilient element **300** extends from the first surface **201** of the wiper support **200** towards the cover **100** and toward the guide pin **210**. A person skilled in the art may understand that, the resilient element **300** may also use any other suitable extension manner.

The free end **302** of the resilient element **300** may present multiple forms, for example the forms as shown in FIGS. **5** and **6**. In one embodiment, the free end **302** has a flat contact surface, which always remains in contact with the surface of the cover **100** facing the wiper support **200**. In the case that there is a flat contact surface, a face contact is formed between the resilient element **300** and the cover **100**. In another embodiment, the free end **302** has a projection **303** (FIG. **3**), which always remains in contact with a surface of the cover **100** facing the wiper support **200**. In the case that there is a projection **303** (see FIG. **3**), point contact is formed between the resilient member **300** and the cover **100**. A person skilled in the art should understand that, the free end **302** of the resilient element **300** may also use any other suitable form.

As described above, the resilient element **300**, which is disposed between the cover **100** and the wiper support **200**, extends from the wiper support **200** to abut the cover **100**. According to the embodiment of the present disclosure, the resilient element **300** is configured to be compressed between the cover **100** and the wiper support **200**, and always remain compressed during the entire operation of the phase shifter **1**.

Since the resilient element **300** is compressed between the cover **100** and the wiper support **200**, the resilient element **300** applies a pressing force to the wiper support **200** so as to bias the wiper support **200** toward the substrate **10**. As described above, the wiper **60** is fixed on the second surface **202** of the wiper support **200**, the PCB **50** is fixed on the substrate **10**, and the wiper **60** abuts against the PCB **50**. Thus, the resilient element **300** applies pressure to the wiper support **200** so that, in turn, pressure is exerted between the wiper **60** and the PCB **50**.

Since the resilient element **300** extends between the cover **100** and the wiper support **200**, a distance between the cover **100** and the wiper support **200** determines a degree at which the resilient element **300** is compressed. In this case, since the wiper **60** is fixed on the second surface **202** of the wiper support **200**, the PCB **50** is fixed on the substrate **10**, and the wiper **60** abuts against the PCB **50**, a distance between the cover **100** and the wiper support **200** actually determines a distance between the cover **100** and the substrate **10**. That is, when the cover **100** is fixed to the substrate **10** by the fastening mechanism **400**, the distance between the cover **100** and the substrate **10** is associated with a degree at which the resilient element **300** is compressed.

In operation of the phase shifter **1**, the wiper **60** is required to press against the PCB **50** with a suitable pressure, so as to maintain a favorable contact between the wiper **60** and the PCB **50** during movement of the wiper **60** relative to the PCB **50**. In the meantime, the pressure between the wiper **60** and the PCB **50** cannot be too high. Otherwise, there may be an excessive friction force between the wiper **60** and the PCB **50**, which results in difficulty for the wiper **60** to move relative to the PCB **50**.

Therefore, it is desirable that the pressure between the wiper **60** and the PCB **50** is adjustable so as to provide a proper pressure according to actual needs. It can be known from the above descriptions that, the degree at which the resilient element **300** is compressed is associated with the pressure between the wiper **60** and the PCB **50**, and moreover, the distance between the cover **100** and the substrate **10** is associated with the degree at which the resilient element **300** is compressed. Thus, the pressure between the wiper **60** and the PCB **50** may be adjusted by adjusting the distance between the cover **100** and the substrate **10**.

According to one embodiment of the present disclosure, the distance between the cover **100** and the substrate **10** may be adjusted by selecting a fastening mechanism **400** of a different size. That is, the distance between the cover **100** and the substrate **10** is determined on the basis of the pressure required between the wiper **60** and the PCB **50**, and a suitable fastening mechanism **400** is selected according to the distance between the cover **100** and the substrate **10**.

According to another embodiment of the present disclosure, the fastening mechanism **400** may be provided with an adjusting means **410** (FIG. **4**), which is configured to adjust a distance between the cover **100** and the substrate **10**. The adjusting means **410** may use any suitable configuration, for example, an adjusting screw, an indexing adjusting means, and the like may be used.

In operation of the phase shifter **1**, the pressure between the wiper **60** and the PCB **50** is desirably uniform, thereby improving the operation accuracy of the phase shifter **1**.

As described above, the wiper **60** is fixed on the second surface **202** of the wiper support **200**, the PCB **50** is fixed on the substrate **10**, and the wiper **60** abuts against the PCB **50**. According to one embodiment of the present disclosure, the second surface **202** of the wiper supporter **200** is configured such that its surface area is greater than the surface area of the wiper **60** so that the wiper **60** can be completely covered by the second surface **202** when the wiper **60** is completely fixed to the second surface **202**. In this case, the pressing force on the wiper support **200** produced due to the compression of the resilient element **300** can be uniformly applied to the entire wiper **60** so that the pressure between the wiper **60** and the PCB **50** is uniform.

According to one embodiment of the present disclosure, the cover **100**, the wiper support **200** and the substrate **10** are arranged parallel to one another, and always remain arranged in parallel during an operation process of the phase shifter **1**.

The cover **100** and the substrate **10** are both made of a rigid material. By the connection of the fastening mechanism **400**, the distance between the cover **100** and the substrate **10** always remains uniform so that the cover **100** and the substrate **10** remain arranged in parallel.

As described above, the guide pin **210** is disposed substantially centrally on the wiper support **200**. In order to maintain a uniform pressing force produced by the resilient element **300** on the entire wiper support **200**, there may be provided with a plurality of resilient elements **300**, which may be resilient elements of the same configuration. As shown in FIGS. **5** and **6**, a plurality of resilient elements **300** are arranged on the wiper support **200** in a regular manner, preferably arranged symmetrically with respect to the guide pins **210**. For example, as shown in FIG. **5**, according to one embodiment of the wiper support device **70**, there are provided with two resilient elements **300**, which are arranged on both sides of the guide pin **210** and symmetrically arranged with respect to the center of the guide pin **210**. For example, as shown in FIG. **6**, according to one embodiment of the wiper support device **70**, there are provided with four resilient elements **300**, which are symmetrically arranged around the center of the guide pin **210**. A person skilled in the art may understand that, the amount and arrangement manner of the resilient elements **300** are not limited thereto, and various other suitable amounts and arrangement manners are also possible according to actual needs in application.

In the case that the cover **100**, the wiper support **200** and the substrate **10** are arranged parallel to one another, with the aid of the symmetrical arrangement of the plurality of resilient elements **300**, the pressing force produced by compression of the resilient elements **300** on the wiper support **200** can be uniformly exerted on the entire wiper **60**, in turn causing a uniform pressure between the wiper **60** and the PCB **50**, during an operation process of the phase shifter.

The phase shifter **1** may have a plurality of primary phase shifters **20** and/or secondary phase shifters **30**. In this case, it may be necessary to ensure that the pressure between all the wipers **60** and the PCB **50** is uniform. To this end, the cover **100** may be configured for a plurality of wiper support devices **70**, preferably for all the wiper support devices **70**. For example, as shown in FIGS. **1** and **2**, one cover **100** is provided. In other words, a plurality of wiper support devices **70** share one cover **100**, thus ensuring that in all the wiper support devices **70**, the distance between the cover **100** and the substrate **10** is uniform and the same, maintaining that the cover **100** and the substrate **10** are arranged in parallel.

In this case, the resilient element **300** in each of the wiper support devices **70** may use the same configuration, so that during operation of the phase shifter, the pressure produced by compression of the resilient elements **300** on the wiper support **200** can be uniformly exerted on the entire wiper **60**, in turn causing a uniform pressure between all the wipers **60** and the PCB **50**.

Those of skill in this art will appreciate that the resilient element may take other forms. For example, when in the form of a resilient finger as described above, the resilient member may be disposed at a different oblique angle relative to the wiper support **200**, which may influence the pressure experience by the wiper. The resilient finger may be tapered in width or depth along its length to produce a desired force when deflected. The locations and/or angular dispositions of the resilient fingers may vary from that shown herein. Moreover, the resilient member may take a sinuous or serpentine form, with multiple bends and angles (much like a spring), and provide pressure due to compression thereof rather than bending. The resilient members may also comprise multiple layers to impact the pressure force (for example, a damping material may be included as the contact surface to assist with uniformity of pressure). Other variations may also be employed.

In one embodiment of the wiper support device **70** according to the present disclosure, the wiper support **200** may be provided with a positioning member **220**, and correspondingly, the cover **100** may be provided with a positioning slot **103**. As shown in FIGS. **2** and **4**, the positioning member **220** may be disposed on an edge of the wiper support **200**, protruding from the first surface **201** of the wiper support **200** toward the cover **100**. When the wiper support device **70** is assembled, the positioning member **220** extends into the positioning slot **103** to facilitate the positioning of the wiper support **200** relative to the cover **100**.

The foregoing is illustrative of the present disclosure and is not to be construed as limiting thereof. Although exemplary embodiments of this invention have been described, those skilled in the art should readily appreciate that many variations and modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such variations and modifications are intended to be included within the scope of this invention as defined in the claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

The invention claimed is:

1. A wiper support device for a phase shifter, the phase shifter including a substrate, the wiper support device comprising:

a cover provided opposite to the substrate;

a wiper support located between the cover and the substrate, the wiper support having a first surface facing the cover and a second surface facing the substrate, the second surface being fixed with a wiper;

a resilient element extending from the first surface of the wiper support toward the cover and abutting against the cover; and

a fastening mechanism connecting the cover to the substrate,

wherein the resilient element is compressed between the cover and the wiper support.

2. The wiper support device according to claim **1**, wherein the resilient element extends obliquely towards the cover

with respect to the first surface of the wiper support and is movable relative to the cover on a surface of the cover.

3. The wiper support device according to claim **1**, wherein the wiper support is provided with a cutout, the resilient element is located within the cutout when viewed along a direction perpendicular to the first surface such that the resilient element, when compressed, is deformable towards the cutout so as to enter into the cutout.

4. The wiper support device according to claim **1**, wherein the wiper support is provided with a guide pin, and the cover is provided with a guide slot, the guide pin passing through the guide slot and being movable within the guide slot.

5. The wiper support device according to claim **1**, wherein the resilient element is a resilient finger extending from the first surface of the wiper support toward the cover, one end of the resilient finger is fixed to the first surface of the wiper support, and the other end of the resilient finger is a free end abutting against the cover and movable on a surface of the cover relative to the cover.

6. The wiper support device according to claim **5**, wherein the free end has a flat contact surface which remains in contact with the surface of the cover facing the wiper support, so as to form a face contact between the resilient element and the cover.

7. The wiper support device according to claim **5**, wherein the free end has a projection which remains in contact with the surface of the cover facing the wiper support, so as to form a point contact between the resilient element and the cover.

8. The wiper support device according to claim **1**, wherein the wiper support is provided with a guide pin, and the cover is provided with a guide slot, the guide pin passing through the guide slot and being movable within the guide slot.

9. The wiper support device according to claim **8**, wherein the guide slot has an end that serves as a stop to limit a movement of the guide pin.

10. The wiper support device according to claim **8**, wherein the guide pin is centrally disposed on the wiper support.

11. The wiper support device according to claim **1**, wherein the cover is connected to the substrate via the fastening mechanism such that a distance between the cover and the substrate is associated with an amount in which the resilient element is compressed.

12. The wiper support device according to claim **1**, wherein the fastening mechanism comprises an adjusting means, which is configured to adjust a distance between the cover and the substrate.

13. The wiper support device according to claim **1**, wherein a PCB is fixed on the substrate, and the wiper abuts against the PCB, wherein the wiper is completely covered by the second surface of the wiper support.

14. The wiper support device according to claim **1**, wherein the cover, the wiper support and the substrate are arranged parallel to each other and remain arranged in parallel during operation of the phase shifter.

15. The wiper support device according to claim **1**, wherein the wiper support device comprises a plurality of resilient elements arranged in a regular manner on the wiper support.

16. The wiper support device according to claim **15**, wherein the plurality of resilient elements have the same configuration.

17. The wiper support device according to claim **15**, wherein the plurality of resilient elements are arranged symmetrically around a center of a guide pin.

18. The wiper support device according to claim **1**, wherein the wiper support is provided with a positioning member, and the cover is provided with a positioning slot, and wherein when the wiper support device is assembled, the positioning member extends into the positioning slot.

19. A phase shifter, the phase shifter comprising:

a driving mechanism; and

the wiper support device according to claim **1**,

wherein the driving mechanism is configured to drive the wiper support.

20. The phase shifter according to claim **19**, wherein the driving mechanism includes a pull rod and a pull rod connector fixedly connected to the pull rod, the pull rod connector being configured to drive the wiper support.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

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APPLICATION NO. : 16/251893
DATED : September 1, 2020
INVENTOR(S) : Guomin Ding

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title Page

(30) Foreign Application Priority Data:
Please add:
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Signed and Sealed this
Sixteenth Day of February, 2021

Drew Hirshfeld
Performing the Functions and Duties of the
Under Secretary of Commerce for Intellectual Property and
Director of the United States Patent and Trademark Office